

AD-A102 745

VANDERBILT UNIV NASHVILLE TN DEPT OF PSYCHOLOGY
CONTOUR INTERACTION IN VISUAL SPACE.(U)

F/6 5/10

JUN 81 R FOX

N00014-76-C-1101

UNCLASSIFIED N14-1101-81C-0003

NL

1 OF 1
ADA
102-85

END
9-81
DTIC

ADA102745

DMC FILE COPY

Report N14-1101 81C-0003

~~LEVEL~~

(6)

Contour Interaction
in Visual Space

Robert Fox

Department of Psychology
Vanderbilt University
Nashville, Tennessee 37240

SELECTED
AUG 12 1981
S C D

June 1981

Technical Report

Reproduction in whole or in part is permitted for any purpose
of the United States government. Distribution of this document
is unlimited.

Prepared for:

Engineering Psychology Programs
Office of Naval Research
800 North Quincy Street, Code 455
Arlington, Virginia 22217

81 8 11 051

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM								
1. REPORT NUMBER <i>14</i> N14-1101-81C-0003	2. GOVT ACCESSION NO. <i>AD-A302745</i>	3. RECIPIENT'S CATALOG NUMBER								
4. TITLE (and Subtitle) <i>Contour Interaction in Visual Space.</i>	5. TYPE OF REPORT & PERIOD COVERED Technical Report									
7. AUTHOR(S) <i>Robert Fox</i>	6. PERFORMING ORG. REPORT NUMBER <i>14 N00014-76-C-1101</i>									
9. PERFORMING ORGANIZATION NAME AND ADDRESS <i>Vanderbilt University Nashville, Tennessee 37240</i>	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS									
11. CONTROLLING OFFICE NAME AND ADDRESS <i>Engineering Psychology Programs, ONR 800 North Quincy Street, Code 455 Arlington, Virginia 22217</i>	12. REPORT DATE <i>1 : June 1981</i>									
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. NUMBER OF PAGES									
	15. SECURITY CLASS. (of this report) <i>Unclassified</i>									
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE									
16. DISTRIBUTION STATEMENT (of this Report) <i>For Public Release; Distribution Unlimited</i>										
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) <i>6/24/1981</i>										
18. SUPPLEMENTARY NOTES										
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <table><tbody><tr><td>Stereopsis</td><td>Depth Separation</td></tr><tr><td>Random element stereograms</td><td>3-dimensional displays</td></tr><tr><td>Destructive interaction</td><td>Vertical horopter</td></tr><tr><td>Distortive interaction</td><td></td></tr></tbody></table>			Stereopsis	Depth Separation	Random element stereograms	3-dimensional displays	Destructive interaction	Vertical horopter	Distortive interaction	
Stereopsis	Depth Separation									
Random element stereograms	3-dimensional displays									
Destructive interaction	Vertical horopter									
Distortive interaction										
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <p>This report summarizes work completed under the support of Contract N00014-76-C-1101, work unit number NR197-036, between Vanderbilt University and the Engineering Psychology Program, Office of Naval Research. The contract started on September 20, 1976 and was completed on April 30, 1981. The goal of the project was to determine if interactions among visual stimuli known to occur in 2-dimensional space are substantially</p>										

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

altered when interacting elements are placed in 3 dimensions. Interaction, or interference, refers to changes in the perceptibility or appearance of stimuli that occur when placed in close spatial proximity to other stimuli. These interactions, which are known to influence the processing of information in visual displays, have been studied extensively in the 2-dimensional case. The extension to 3 dimensions, however, has been limited by technical problems associated with manipulation of stimuli simultaneously in X, Y, and Z axes.

The project overcame these limitations by using, as interacting stimuli, stereoscopic forms generated from random element stereograms. This permitted facile manipulation of stimuli in stereoscopic space without introducing potentially confounding changes in proximal stimulation. The interactive phenomena investigated were: (1) destructive interactions (threshold elevation) under transient threshold level conditions; (2) destructive interactions under suprathreshold conditions, (3) distortive interactions (changes in apparent length) under suprathreshold conditions, and (4) interactions imposed by the geometry of 3-dimensional space.

The major findings were as follows: (a) Separating the interacting stimuli in depth substantially modified their interaction; When a test stimulus was in a depth plane in front of inducing stimuli and closer to the observer, interaction declined as a monotonic function of the difference in depth separation between test and inducing stimuli. When depth positions were reversed and the test stimulus appeared in a depth plane behind the inducing stimuli and farther from the observer, the magnitude of the interaction tended to increase. This asymmetrical effect of depth position, which has been termed the "front effect", applied to both threshold and suprathreshold destructive interactions and to suprathreshold distortive interactions.

(b) The vertical dimension of stereoscopic visual space is tilted away from the observer. This tilt produces a difference in the threshold level perceptibility of stimuli above and below the horizontal line of fixation. Stimuli located above horizontal fixation and in crossed disparity had lower thresholds than those below fixation. This bias could be reversed by physical tilt of the stereoscopic display, and it did not alter suprathreshold characteristics of the stimuli.

Implications of these data for models of visual space and for the processing of information from 3-dimensional displays are discussed in the reports and papers summarized in this report.

Accession For	111	111	111
RTV'S	341	341	341
Print	3	3	3
Document	3	3	3
Classification	3	3	3
By	3	3	3
Distribution/	Availability Codes	Availability Codes	Availability Codes
Print	Print and/or	Print and/or	Print and/or
Document	Special	Special	Special
Classification	Special	Special	Special

A

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

This Final Report describes work completed under the support of Contract N00014-76-C-1101, work unit number NR197-036, between Vanderbilt University and the Engineering Psychology Program, Office of Naval Research. The contract was initiated on September 20, 1976 and was completed on April 30, 1981.

Contour Interaction in Visual Space

Introduction

As the title indicates, this project investigated the interaction of visual stimuli as a function of their location in 3-dimensional space. Interaction is a general term referring to perceived changes in the attributes of a stimulus induced by adjacent stimuli which provide a context for it. These interactions can be destructive as manifested by a reduction in perceptibility of the stimulus at both the threshold and suprathreshold levels, or interactions can be distortive as manifested by changes in the apparent size or shape of a stimulus. One example of destructive interference is the phenomenon of visual masking, characterized by an elevation in the threshold of a transient stimulus when it is closely coupled in space or time with a second stimulus. Many examples of distortive interaction are provided by the geometric visual illusions. These kinds of interactive phenomena, which significantly influence the processing of information from visual displays, have been investigated extensively over the years. Yet almost all investigations have been confined to two dimensions in which the interacting stimuli are varied in X and Y axes while the Z-axis or depth dimension remains the same for all stimuli.

But there are some data and theory that suggest such interactions can be substantially changed or modified when the stimuli are in three dimensions, i.e., their Z-axis value varied. Furthermore, there is reason to believe that 3-dimensional space itself can exert a distorting influence on all stimuli within it. These effects would clearly influence the processing of visual information from stereoscopic displays. But their systematic investigation has been retarded by the difficulty involved in placing interacting contours in three dimensions without introducing confounding cues.

That difficulty was overcome in this project through application of a new technique for generating stereoscopic displays. Using that technique, the project investigated interaction of multiple contours in space and time at threshold and suprathreshold levels as a function of their loci in 3 dimensions.

General Approach

The key feature of the experimental method was the presentation of interacting stimuli as stereoscopic figures formed from dynamic random element stereograms. These stereograms consist of matrices of randomly ordered elements that contain no discernible contours when viewed under

nonstereoscopic conditions. When viewed under stereoscopic conditions, however, clear-cut stereoscopic forms at different positions in depth can readily be seen. The stereoscopic forms arise at a central stage within the visual system and do not engage peripheral stages (i.e., the retina). This feature permits changes in stimulus position and configuration to be made without introducing confounding changes in peripheral stimulation. In dynamic versions of the stereograms, all elements are randomly replaced many times a second; this rapid replacement provides a kind of camouflage which permits stereoscopic stimuli to be moved about in space and quickly presented without introducing nonstereoscopic cues.

The initial applications of dynamic random element stereograms were severely restricted by the expensive and cumbersome cinematographic and computer techniques necessary for their production. But recent advances in electronics have made it possible to generate stereograms using self-contained portable hardwired electronic devices. Such a system for stereogram generation has been developed at Vanderbilt and is part of an ongoing development program. A number of systems, varying in sophistication, have been devised. A description of one system is given in Shetty, Brodersen, and Fox (1979a, b).

All versions of the systems use as display devices modified video color receivers. These provide for the generation of red and green dot matrices, which when viewed through appropriate red and green filters, fulfill the requirements for stereoscopic viewing (i.e., the anaglyph method of stereoscopic presentation). Almost any conceivable physical form can be presented as a stereoscopic form by means of an optical programming device that acts to convert physical forms scanned by the device into their stereoscopic counterpart. Parameters of the stereoscopic form such as disparity magnitude and direction, position in X-Y coordinates, and exposure duration, can be quickly changed by the stereogram generation system. This flexibility allows the same rigorous psychophysical methodology used for conventional stimuli to be applied to stereoscopic stimuli.

Although stereoscopic stimuli arise from a central stage within the visual system, they are functionally equivalent in many ways to conventional physical stimuli defined by changes in luminance. For instance, stereoscopic contours can induce eye movements, aftereffects, and visual illusions. Some question, however, has been raised as to whether stereoscopic stimuli might be more susceptible to cognitive influences such as set and expectancy. But convincing evidence that such factors exert no special influence on stereoscopic stimuli was provided by Staller, Lappin, and Fox (1979, 1980), who found that both physical and stereoscopic stimuli are processed in the same way.

In summary, stereoscopic stimuli formed from dynamic random element stereograms are an excellent vehicle for investigating the effect of depth position on stimulus interaction. Large changes in apparent depth can readily be made without introducing confounding (i.e., retinal) stimulation. Further, data obtained from stereoscopic stimuli can be generalized to the interaction of conventional stimuli. These features make stereoscopic stimuli the method of choice for the inquiry into the effect

of depth position described in subsequent sections.

Multiple Contour Interaction: Destructive interference at the threshold level

One of the most extensively investigated instances of destructive interference at threshold is visual metacontrast masking, wherein a slightly above threshold transient test stimulus is presented in close temporal and spatial proximity to a masking stimulus. Presentation of the mask after presentation of the test (backward masking) or before the test (forward masking) substantially raises the threshold of the test relative to the threshold obtained when the test is presented alone. The specific stimulus conditions that influence forward and backward masking are well-known and several well-articulated theoretical models have been developed. This research effort, however, has dealt exclusively with two dimensions, X and Y; the Z-axis value of both masking and test stimuli has remained the same. Since masking has been extensively studied in two dimensions, it is an ideal phenomenon for investigating the effect of differences in apparent depth position of test and mask. Such an investigation was carried out in experiments using test and mask configured from random element stereograms by Fox and Lehmkuhle (1978) and Lehmkuhle and Fox (1980). The main results of that investigation were as follows:

1. When test and mask had the same depth or Z-axis values, substantial masking was obtained. Further, many of its spatial and temporal characteristics were similar to those associated with the masking of physical contours. This similarity supports the view that stereoscopic stimuli are functionally equivalent to physical stimuli.

2. Forward masking occurred over a temporal range approximately three times that found during the masking of physical stimuli. This is consistent with other data that indicate the temporal response in stereopsis is relatively slow compared to nonstereoscopic stimulation.

3. Placing test and mask at different depths had a substantial effect on the magnitude of masking. When the test occupied a depth position that placed it in front of the mask and closer to the observer, masking decreased as a monotonic function of increases in depth between the test and the mask. When the relative depth positions were reversed and the test form was located behind the mask and further from the observer, masking was enhanced. The asymmetrical effect of depth position on masking was a new and unexpected observation that was termed the "front effect".

4. It was hypothesized that the front effect might reflect a bias of the visual system to give preferential treatment to the stimulus that is in front of another and closer to the observer.

Multiple Contour Interaction: Destructive interference under suprathreshold conditions

In this series of experiments, described in Fox and Patterson (1980), the effect of depth separation on lateral interference was examined. Lateral interference refers to the inhibitory interaction among spatially adjacent suprathreshold stimuli, as for example, that which occurs in strings of alphanumeric symbols. Interference

was produced by a continuously present suprathreshold circular stimulus whose contours surrounded a test stimulus. The effect of the interfering stimulus on the test stimulus was defined by two indices: (a) forced-choice recognition threshold of the test stimulus in the presence and absence of the interfering stimulus, and (b) ratings of the clarity of the test stimulus while it was continuously visible. The main results were as follows:

1. When both interfering and test stimuli were in the same depth plane, considerable interference was obtained.
2. Increases in the distance between the inner contour of the interfering stimulus and the outer contour of the test stimulus produced a monotonic decline in interference. This is consistent with the hypothesis advanced by Fox and Lehmkuhle that the inhibitory interaction seen in the front effect occurs only when stimuli are spatially close and have potentially competing visual directions.
3. Separation in depth of the interfering and test stimuli had a substantial effect on the magnitude of interference. The effect was asymmetrical and followed the pattern of the front effect described earlier. This outcome indicates that the front effect is not restricted to the transient threshold level stimulation associated with visual masking.

Multiple Contour Interaction: Distortive interference

The previous experiments demonstrated that depth position exerted a strong influence on destructive interactions. Whether this influence would apply to distortive interactions was the experimental question that was pursued later. The stimulus configuration chosen as a clear example of distortive interaction was one in which a change in the apparent length of line segments is induced when they are placed within the arms of an acute angle. Such a distortion occurs in many natural situations involving linear perspective gradients and, within the context of research in geometric visual illusions, it is known as the Ponzo illusion. As described by Fox and Patterson (1981a), the inducing triangle and the test lines enclosed within it were formed from dynamic random element stereograms, and the relative depth positions of the triangle and the lines varied. The main results were as follows:

1. When all contours were in the same depth plane, substantial distortion occurred of the same order of magnitude as that observed for physical contours. This similarity in magnitude supports the hypothesis that stereoscopic contours are functionally equivalent to their physical counterparts.
2. When the depth planes of the triangle and the test lines were varied, and the lines appeared in depth planes in front of the triangle, distortion decreased as a monotonic function of the depth difference between triangle and lines. When the depth positions were reversed, and the triangle appeared in a depth plane in front of the lines, distortion tended to increase. This pattern of results was virtually identical to that observed for the front effect.

Overall, the results support two general conclusions. First, depth

position appears to have a substantial effect on all classes of interactions. Second, the pattern of that influence as defined by the front effect appears to be a very general characteristic of depth position.

Effect of the Tilted Vertical Horopter

The previous experiments dealt with the effect of depth position on the interactions among stimuli and the asymmetrical nature of that effect. The experiments in this section examined an asymmetrical effect of 3-dimensional space itself on all stimuli within it. Recent research has suggested that the vertical dimension, or horopter, of visual space does not coincide with the gravitational vertical but tilts away from the observer, with the degree of tilt varying with observation distance. One consequence of the tilt would be to differentially bias the processing of stimuli above and below the horizontal line of fixation. Stimuli with crossed disparity located above horizontal fixation would be relatively more perceptible than those with crossed disparity below fixation. The characteristics of this tilt were investigated in five experiments that are described in Fox and Patterson (1981b). The main results were as follows:

1. Perceptibility of stimuli, defined in terms of changes in forced-choice recognition thresholds, did vary as a function of their location relative to the horizontal line of fixation: Stimuli above fixation had lower thresholds than those below it. This result is consistent with the hypothesis that the vertical horopter is tilted away from the observer.
2. The bias, or asymmetry, could be reversed by either physically tilting the visual display, or by changing the relative disparity between the fixation stimulus and the test stimuli. Theoretically, these results support the hypothesis that the vertical horopter remains tilted in a fixed position despite changes in physical tilt or in the location of the fixation stimulus. Empirically, the results suggest techniques that could be used to correct or compensate for the asymmetry.
3. The asymmetry does not seem to change the apparent size of objects as a function of their position (i.e., above and below fixation) in the display, nor did the depth relationships seem to require maintaining a fixed position of the head and eyes.

Overall, the results indicate that the tilted horopter, and its attendant effects on the processing of visual stimuli, is an intrinsic property of all stereoscopic and 3-dimensional displays.

REPORTS PREPARED

Fox, R., & Lehmkuhle, S. Contour interaction in visual space: Depth separation and visual masking (Tech. Rep. N14-1101 78C-0001). Nashville, TN: Vanderbilt University, Department of Psychology, July 1978. AD A059519.

Staller, J.D., Lappin, J.S., & Fox, R. Stimulus uncertainty does not affect the time required to perceive stereopsis (Tech. Rep. N14-1101 79C-0002). Nashville, TN: Vanderbilt University, Department of Psychology, July 1979. AD A073707.

Shetty, S.S., Brodersen, A.J., & Fox, R. System for generating dynamic random element stereograms (Tech. Rep. N14-1101 79C-0003). Nashville, TN: Vanderbilt University, Department of Psychology, September 1979. (a) AD A075686.

Shetty, S.S., Brodersen, A.J., & Fox, R. System for generating dynamic random element stereograms. Behavior Research Methods & Instrumentation, 1979, 11, 485-490. (b)

Fox, R., & Patterson, R. The effect of depth separation on lateral interference (Tech. Rep. N14-1101 80C-0001). Nashville, TN: Vanderbilt University, Department of Psychology, July 1980.

Staller, J.D., Lappin, J.S., & Fox, R. Stimulus uncertainty does not impair stereopsis. Perception & Psychophysics, 1980, 27, 361-367.

Lehmkuhle, S., & Fox, R. Effect of depth separation on metacontrast masking. Journal of Experimental Psychology: Human Perception and Performance, 1980, 6, 605-621.

Fox, R., & Patterson, R. Effect of depth separation on the Ponzo illusion (Tech. Rep. N14-1101 81C-0001). Nashville, TN: Vanderbilt University, Department of Psychology, April 1981. (a)

Fox, R., & Patterson, R. Effect of the tilted vertical horopter on visual recognition (Tech. Rep. N14-1101 81C-0002). Nashville, TN: Vanderbilt University, Department of Psychology, May 1981. (b)

PAPERS PRESENTED

Lehmkuhle, S., & Fox, R. Visual masking with stimuli formed from dynamic random element stereograms. Paper presented at the meeting of the Association for Research in Vision and Ophthalmology, Sarasota, April 1978.

Staller, J., Lappin, J.S., & Fox, R. Sensory processing in global stereopsis. Paper presented at the meeting of the Association for Research in Vision and Ophthalmology, Sarasota, April 1978.

Shea, S.L., & Fox, R. The cyclopean retina: Evidence for a functional fovea. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, May 1978.

Fox, R. Contour interaction in visual space. Paper presented at the meeting of the Human Factors Society, Detroit, October 1978.

Patterson, R., & Fox, R. Effect of depth separation on contour interaction. Paper presented at the meeting of the Psychonomic Society, Phoenix, November 1979.

Fox, R., & Patterson, R. Effect of depth separation on the Ponzo illusion. Paper presented at the meeting of the Psychonomic Society, St. Louis, November 1980.

PERSONNEL ASSOCIATED WITH PROGRAM

Principal Investigator:

Dr. Robert Fox
Professor of Psychology
and of Biomedical Engineering

Students:

Stephen Lehmkuhle
Robert Patterson
Sudhakar Shetty
Joshua Staller

OFFICE OF NAVAL RESEARCH

Code 455

TECHNICAL REPORTS DISTRIBUTION LIST

OSD

CDR Paul R. Chatelier
Office of the Deputy Under Secretary
of Defense
OUSDRE (E&LS)
Pentagon, Room 3D129
Washington, D.C. 20301

Department of the Navy

Director
Engineering Psychology Programs
Code 455
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217 (5 cys)

Director
Aviation & Aerospace Technology
Code 210
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Undersea Technology
Code 220
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Electronics & Electromagnetics
Technology
Code 250
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Department of the Navy

Director
Communication & Computer Technology
Code 240
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Manpower, Personnel and Training
Code 270
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Information Systems Program
Code 437
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Director
Physiology Program
Code 441
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Special Assistant for Marine
Corps Matters
Code 100M
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

Commanding Officer
ONR Eastern/Central Regional Office
ATTN: Dr. J. Lester
Building 114, Section D
666 Summer Street
Boston, MA 02210

Department of the Navy

Commanding Officer
ONR Branch Office
ATTN: Dr. C. Davis
536 South Clark Street
Chicago, IL 60605

Commanding Officer
ONR Western Regional Office
ATTN: Dr. E. Gloye
1030 East Green Street
Pasadena, CA 91106

Office of Naval Research
Scientific Liaison Group
American Embassy, Room A-407
APO San Francisco, CA 96503

Director
Naval Research Laboratory
Technical Information Division
Code 2627
Washington, D.C. 20375 (6 cys)

Dr. Robert G. Smith
Office of the Chief of Naval
Operations, OP987H
Personnel Logistics Plans
Washington, D.C. 20350

Dr. Jerry C. Lamb
Combat Control Systems
Naval Underwater Systems Center
Newport, RI 02840

Naval Training Equipment Center
ATTN: Technical Library
Orlando, FL 32813

Human Factors Department
Code N215
Naval Training Equipment Center
Orlando, FL 32813

Dr. Alfred F. Smode
Training Analysis and Evaluation
Group
Naval Training Equipment Center
Code N-00T
Orlando, FL 32813

Department of the Navy

Dr. Gary Pooch
Operations Research Department
Naval Postgraduate School
Monterey, CA 93940

Dean of Research Administration
Naval Postgraduate School
Monterey, CA 93940

Mr. Paul Heckman
Naval Ocean Systems Center
San Diego, CA 92152

Mr. Warren Lewis
Human Engineering Branch
Code 8231
Naval Ocean Systems Center
San Diego, CA 92152

Dr. Robert French
Naval Ocean Systems Center
San Diego, CA 92152

Dr. Ross L. Pepper
Naval Ocean Systems Center
Hawaii Laboratory
P.O. Box 997
Kailua, HI 96734

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code RD-1
Washington, D.C. 20380

Mr. Arnold Rubinstein
Naval Material Command
NAVMAT 0722 - Rm. 508
800 North Quincy Street
Arlington, VA 22217

Commander
Naval Air Systems Command
Human Factors Programs
NAVAIR 340F
Washington, D.C. 20361

Commander
Naval Air Systems Command
Crew Station Design,
NAVAIR 5313
Washington, D.C. 20361

Department of the Navy

Mr. Phillip Andrews
Naval Sea Systems Command
NAVSEA 0341
Washington, D.C. 20362

Commander
Naval Electronics Systems Command
Human Factors Engineering Branch
Code 4701
Washington, D.C. 20360

CDR Robert Biersner
Naval Medical R&D Command
Code 44
Naval Medical Center
Bethesda, MD 20014

Dr. Arthur Bachrach
Behavioral Sciences Department
Naval Medical Research Institute
Bethesda, MD 20014

Dr. George Moeller
Human Factors Engineering Branch
Submarine Medical Research Lab
Naval Submarine Base
Groton, CT 06340

Head
Aerospace Psychology Department
Code L5
Naval Aerospace Medical Research Lab
Pensacola, FL 32508

Dr. James McGrath, Code 302
Navy Personnel Research and
Development Center
San Diego, CA 92152

Navy Personnel Research and
Development Center
Planning & Appraisal
Code 04
San Diego, CA 92152

Navy Personnel Research and
Development Center
Management Systems, Code 303
San Diego, CA 92152

Department of the Navy

Navy Personnel Research and
Development Center
Performance Measurement &
Enhancement
Code 309
San Diego, CA 92152

Dr. Julie Hopson
Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

Mr. Jeffrey Grossman
Human Factors Branch
Code 3152
Naval Weapons Center
China Lake, CA 93555

Human Factors Engineering Branch
Code 1226
Pacific Missile Test Center
Point Mugu, CA 93042

Mr. J. Williams
Department of Environmental
Sciences
U.S. Naval Academy
Annapolis, MD 21402

Dean of the Academic Departments
U.S. Naval Academy
Annapolis, MD 21402

Human Factors Section
Systems Engineering Test
Directorate
U.S. Naval Air Test Center
Patuxent River, MD 20670

Human Factor Engineering Branch
Naval Ship Research and Development
Center, Annapolis Division
Annapolis, MD 21402

CDR W. Moroney
Code 55MP
Naval Postgraduate School
Monterey, CA 93940

Department of the Navy

Mr. Merlin Malehorn
Office of the Chief of Naval
Operations (OP-115)
Washington, D.C. 20350

Department of the Army

Mr. J. Barber
HQs, Department of the Army
DAPE-MBR
Washington, D.C. 20310

Dr. Joseph Zeidner
Technical Director
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Director, Organizations and
Systems Research Laboratory
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Technical Director
U.S. Army Human Engineering Labs
Aberdeen Proving Ground, MD 21005

U.S. Army Medical R&D Command
ATTN: CPT Gerald P. Krueger
Ft. Detrick, MD 21701

ARI Field Unit-USAREUR
ATTN: Library
C/O ODCSPER
HQ USAREUR & 7th Army
APO New York 09403

Department of the Air Force

U.S. Air Force Office of Scientific
Research
Life Sciences Directorate, NL
Bolling Air Force Base
Washington, D.C. 20332

Chief, Systems Engineering Branch
Human Engineering Division
USAF AMRL/HES
Wright-Patterson AFB, OH 45433

Department of the Air Force

Air University Library
Maxwell Air Force Base, AL 36112

Dr. Earl Alluisi
Chief Scientist
AFHRL/CCN
Brooks AFB, TX 78235

Foreign Addressees

North East London Polytechnic
The Charles Myers Library
Livingstone Road
Stratford
London E15 2LJ
ENGLAND

Professor Dr. Carl Graf Hoyos
Institute for Psychology
Technical University
8000 Munich
Arcisstr 21
FEDERAL REPUBLIC OF GERMANY

Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Technology
Establishment
Teddington, Middlesex TW11 0LN
ENGLAND

Director, Human Factors Wing
Defence & Civil Institute of
Environmental Medicine
Post Office Box 2000
Downsview, Ontario M3M 3B9
CANADA

Dr. A. D. Baddeley
Director, Applied Psychology Unit
Medical Research Council
15 Chaucer Road
Cambridge, CB2 2EF
ENGLAND

Other Government Agencies

Defense Technical Information Center
Cameron Station, Bldg. 5
Alexandria, VA 22314 (12 cys)

Other Government Agencies

Dr. Craig Fields
Director, Cybernetics Technology
Office
Defense Advanced Research Projects
Agency
1400 Wilson Blvd
Arlington, VA 22209

Dr. Lloyd Hitchcock
Federal Aviation Administration
ACT 200
Atlantic City Airport, NJ 08405

Dr. M. Montemerlo
Human Factors & Simulation
Technology, RTE-6
NASA HQS
Washington, D.C. 20546

Other Organizations

Dr. T. B. Sheridan
Department of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Dr. Arthur I. Siegel
Applied Psychological Services, Inc.
404 East Lancaster Street
Wayne, PA 19087

Dr. Harry Snyder
Department of Industrial Engineering
Virginia Polytechnic Institute and
State University
Blacksburg, VA 24061

Dr. Robert T. Hennessy
NAS - National Research Council
JH #819
2101 Constitution Ave., N.W.
Washington, DC 20418

Dr. Robert Williges
Human Factors Laboratory
Virginia Polytechnical Institute
and State University
130 Whittemore Hall
Blacksburg, VA 24061

Other Organizations

Journal Supplement Abstract Service
American Psychological Association
1200 17th Street, N.W.
Washington, D.C. 20036 (3 cys)

Dr. Thomas P. Piantanida
SRI International
BioEngineering Research Center
333 Ravensworth Avenue
Menlo Park, CA 94025

Dr. Edward R. Jones
Chief, Human Factors Engineering
McDonnell-Douglas Astronautics
Company
St. Louis Division
Box 516
St. Louis, MO 63166

Dr. Richard W. Pew
Information Sciences Division
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. David J. Getty
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. A. K. Bejczy
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91125

Dr. Stanley N. Roscoe
New Mexico State University
Box 5095
Las Cruces, NM 88003

